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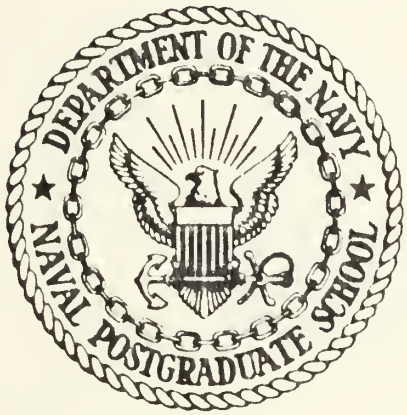

RESEARCH IN THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING (1983-1984)

John P. Powers

May 1985

Prepared for:
Chairman, Department of Electrical and Computer Engineering
Naval Postgraduate School
Monterey, CA 93943

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This report summarizes sponsored research performed in the Department of Electrical and Computer Engineering at the Naval Postgraduate School in FY 84. Areas of research include signal processing, communications, radar and electronic warfare, computer enginering, electromagnetics, controls and C^3.

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

Department of Electrical and
Computer Engineering

Preface

This report provides a snapshot of some of the research that was done at in the Department of Electrical and Computer Engineering during Fiscal Year 1984 (1 October 1983-30 September 1984). The purpose of the report is to introduce the reader to the types of research performed by the Faculty and students, to provide specific information about the projects, and to indicate the breadth of the research effort. The report also contains information on the publications of the faculty and the student theses produced in association with the School's research program. Further information about specific projects or copies of the publications are available from the individual faculty investigators. The mail address of the department is:

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I hope that you find this report interesting and informative.

JOHN P. POWERS
Associate Chairman, Research

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Introduction

The research program of the Department of Electrical and Computer Engineering involves projects in the following areas: signal processing; electromagnetics; communications; computer engineering; radar and electronic warfare; and command, control, communications and intelligence (C^3I) systems. Summaries of the current projects follow.

SIGNAL PROCESSING

Professor **Lonnie Wilson's** project on automatic radar ship classification capabilities for cruise missiles focussed on the development of new target classification capabilities for cruise missile applications. Processing techniques have been developed for automatic target classification based on pattern recognition and advanced correlation techniques. Artificial intelligence concepts have been introduced to aid the decision-making. Professor's Wilson's work has developed several ship target classification algorithms that have been successfully tested on a small number of ship targets.

Professor **Syd Parker** continued work on projects while on sabbatical leave at Stanford University. This work includes development of multidimensional and nonlinear signal processing algorithms for system modeling, identification and digital filtering. Additionally work has been done on extending the one-dimensional lattice parameter modelling used in voice processing to two dimensions for enhance processing of voice, images, two dimensional recursive filter design and two dimensional spectral estimation.

NAVELEX Chair Professor **Ron Mohler** work on nonlinear signal processing techniques applied to the underwater acoustic tracking problem of tracking a maneuvering platform.

Adjunct Professor **Sherif Michael** has been investigating improved operational amplifier specifications that can result when standard op amps are combined into composite operational amplifier configurations. The performance of the combination can be made superior to that of the single op amps. Work is proceeding on the characterization of generalized imittance convertors in both theory and experiment.

COMMUNICATIONS

Adjunct Professor **Daniel Bukhofzer** has been working on an analysis of a receiver in the presence of noise and an intentional interference signal. The goal is analyze the vulnerability of receivers to jamming, and then to optimize the receiver design to operate in the presence of jamming waveforms. He examined per-

formance analyses of coherent and incoherent binary receivers and has extended the technique to multilevel transmission schemes such as M-ary ASK and FSK.

Professor **Hung-Mou Lee** and Professor **Dick Adler** have been studying the properties of antenna patterns of field-expedient antennas used by the Marine Corps and have implemented a design selection technique suitable for use on a microcomputer.

Professor **Larry Ziomek** worked on modelling underwater acoustic propagation and scattering using linear systems models. Problems in pulse propagation, underwater acoustic communication, and target detection were studied using computer simulation of a mathematical model that has been derived. A three-dimensional beamformer algorithm was developed for use in studying these problems.

Professor **John Powers** investigated problems in underwater data transmission by fiber optic cables. One project investigated the survivability of a candidate fiber cable when towed by a ship by an experimental investigation. Similar cables are also being investigated for over-the-shore applications. Instrumentation has been developed for measuring the bit-error performance of ocean-floor systems using a battery-operated CMOS microprocessor that will perform the bit-error test at preprogrammed intervals.

Professor **Paul Moose** initiated research on the development of a high data rate underwater acoustic communications link using a coherent multi-tonal PSK emitter. Work was done on designing and testing the message generator while other components were gathered for assembly of a laboratory prototype.

Adjunct Professor **Dick Adler** performed work on numerical models of antennas for various military applications. Variuos candidates were studied and evaluated for performance.

RADAR AND ELECTRONIC WARFARE

Professor **Michael Morgan** investigated techniques of target identification by resonant responses to electromagnetic waves. Work has continued on the analysis of the response of simple geometries to pulse irradiation. Additionally improvements have been made to the hardware used in collecting experimental data and in the signal processing of this data. In another project Professor Morgan is using the transient scattering response of models to predict the radar cross section of actual targets. Work has concentrated on s-plane measurements and deconvolution techniques to remove the effects of the input pulse.

Professor **Hung-Mou Lee** has been working on the errors that can occur in extrapolating the predictions based on point-source assumptions made in the analyses of monopulse radars to the detection of extended objects (as is commonly done in the literature).

COMPUTER ENGINEERING

Professor **Chin-Hwa Lee** has been working on problems in image processing. In one project he has established test procedures to be used to evaluate contractor algorithms for image segmentation techniques. Another project involves research on on region segmentation to decrease processing loads. He is investigating recursive splitting techniques using a special data structure made possible by virtual memory computers. Techniques for handling the discontinuous boundaries created by some of the techniques have also been studied. In another project, he has studied techniques of achieving data compression of the information in an image by splitting the image into irregular patches.

Professors **Don Kirk** and **Bob Strum** have been applying VLSI design techniques. A pipelined multiplier chip was designed, fabricated, and tested sucessfully.

Adjunct Professor **Herschel Loomis** has ben working on computer architecture and algorithm issues for tactical applications of space systems. Additionally he has been working on problems of computer signal processing of signals using the cyclic spectrum of noisy signals, investigating architecture issues that could improve signal processing and defining a special-purpose language for signal analysis.

ELECTROMAGNETICS

Professor **Hung-Mou Lee** has been studing the theory of scattering from finite-length cylinders to analytically predict the waves. The theory computes the induced surface currents and from them the scattered fields. Efforts are being made to correlate the predicted fields with observations.

Professor **John Powers** and NRC Research Associate **Daniel Guyomar** worked on the propagation of pulsed scalar waves in lossy and lossless media. Computer algorithms were developed for predicting the field for different loss models and boundary conditions. The resulting approaches can be applied to acoustics, optics and electromagnetic waves.

CONTROLS

Professors **Don Kirk** and **Bob Strum** have studying performance measures for the design of constant-gain estimators through design simulations. Additionally, measures were developed to determine the observability of the state of a system. Finally CAD tools were developed for the design and analysis of control systems with constant-gain estimators.

Professor **Alex Gerba** worked on the simulation of a brushless DC motor for application as a fin controller on a cruise missile. This work developed models of the candidate motors with the use of CSMP models for evaluation. Additionally work was done on designing and evaluating a pulse-width-modulation speed controller for these motors.

COMMAND, CONTROL AND COMMUNICATIONS

NAVELEX Chair Professor **Ron Mohler** worked on applying bilinear systems theory to problems in C^3. The technique can be applied to maneuvering rigid bodies, combating forces, adaptive command and control systems, and the hierarchy of the national C^3 system. Additional work has also been done on applying bilinear system theory to pursuit-evasion problems, particularly to multiple pursuer cases where the command and control requirements increase rapidly with the number of pursuers.

Professors **Paul Moose** and **John Wozencraft** worked on mathematical modelling of the forces engaged in dynamic warfare. The model shows that the evolution of a battle is primarily a function of the initial conditions and that optimum decisions can be made from knowledge of those conditions. The resulting paradigm has been successfully tested against historical battles held since World War II.

Professor **Lonnie Wilson** is working on research in sensor integration to track multiple targets. The purpose is to integrate sensor information from ESM, radar, IR/EO, and acoustic sensors in a central location for advanced combat direction. Aspects of implementing the integration with computers and applying artificial intelligence concepts are being investigated.

Title:	Field Expedient Antenna Investigations
Investigators:	R. W. Adler, Adjunct Research Professor and H. M. Lee, Assistant Professor, Electrical and Computer Engineering Department.
Sponsor:	Naval Ocean Systems Center
Objective:	Numerical modeling research on field expedient USMC antennas for development of an antennna selection and design algorithm for use with the prophet system.
Summary:	27 HF and VHF antenna models were developed. A class of these were subjected to field performance measurements. The sensitivity to ground environments was established and used for selection of candidates for inclusion in a files antenna handbook.
Thesis Directed:	W. P. Averill, "Computer Aided Antenna Design And Frequency Slection For HF Communications", Master Thesis, June 1984

Title:	Numerical Models For HF Antennas
Investigators:	R. W. Adler, Adjunct Research Professor, Electrical and Computer Engineering Department.
Sponsor:	Us Army CEEIA
Objective:	Develop numerical models for sky and ground wave communication antennas and conduct a parameter investigation for various tactical applications.
Summary:	Fan doubler, squashed rhombic, sloping longwire and inverted L antennas were modeled. Problems with catenary effects on the long spans require development of an additional code, scheduled for completion June 1985.

Title:	Protable VLF Antenna Modeling
Investigator:	R. W. Adler, Adjunct Research Professor, Electrical and Computer Engineering Department.
Sponsor:	Naval Ocean Systems Center
Objective:	Development of performance specifications for a portable VLF antenna system using numerical modeling techniques.
Summary:	Numerical models of ground screens both buried and above ground were developed in the form of a parameter variation study.
Report:	Letter report of 10 June 1984 to NOSC. From R. W. Adler

TITLE: Performance of Optimum and Suboptimum Incoherent Digital Communications Receivers in the Presence of Noise and Jamming

INVESTIGATOR: D. C. Bukofzer, Assistant Professor of Electrical and Computer Engineering

SPONSOR: Naval Electronic System Command

OBJECTIVE: To determine jamming vulnerability of conventional digital communication receivers.

SUMMARY: Optimum jamming strategies for binary communication receivers were derived and analyzed and alternate jamming waveforms were investigated. Performance analyses were undertaken in order to determine jammer effectiveness. Coherent and Incoherent Binary Receivers were analyzed as well as multilevel schemes such as M-ary ASK and FSK.

PUBLICATIONS:

D. C. Bukofzer, "Performance of Optimum and Sub-optimum Incoherent Digital Communication Receivers in the Presence of Noise and Jamming," IEEE Transactions on Aerospace and Electronic Systems, in progress.

D. C. Bukofzer, "On the Jamming of Digital Communication Receivers: Results for Coherent Binary and Multilevel Modulation," IEEE International Symposium on Information Theory, forthcoming.

D. C. Bukofzer, "Performance of Noncoherent Binary Receivers Under Various Types of Jammers," IEEE International Symposium on Information Theory, forthcoming.

THESES DIRECTED:

F. T. Farwell, "An Analysis of Coherent Digital Receivers in a Jamming Environment," Master's Thesis, June 1984.

H. Y. Joo, "Performance of Noncoherent Digital Receivers in the Presence of Jamming," Master's Thesis, December 1984.

D. Macone, "A Study of the Use of Filter in Digital Receivers Operating in a Jamming Environment," Master's Thesis, December 1984.

TITLE: Brushless DC Motor Simulation Project

INVESTIGATOR: Alex Gerba, Associate Professor of Electrical and Computer Engineering.

SPONSOR: Naval Weapons Center

OBJECTIVE: To simulate a brushless DC motor as a fin controller for a cruise-type missile.

SUMMARY: The development of a CSMP model using average power conditioner and motor characteristics at constant speed has been completed. Several versions of the model that are useful for steady-state speed, current and power versus torque analysis and design were developed. These models include the condition of constant air gap flux as well as sinusoidal and sinusoidal with harmonic air gap flux. Rotor position sensors based upon Hall Effect were simulated to switch power transistor for communication in accordance with logic dictated by a four-pole magnet rotating under Y-connected 3 phase windings.

Concurrent to the above effort, the CSMP model of a speed controller using Pulse Width Modulation (PWM) has been completed. Studies were conducted to establish the effectiveness of this method of speed control under constant flux operation. Results of the investigation verified that power losses within the switching transistors are minimized with resulting savings in transistor cost and heat sink requirements.

THESIS DIRECTED: S. M. Thomas, CSMP Modeling of Brushless DC Motors, MSEE Thesis, Sept. 1984.

Andrew Askinos, Pulse Width Modulated Speed Control of Brushless DC Motors, MSEE Thesis, Sept. 1984.

TITLE: Control System and VLSI Design Studies

INVESTIGATORS: D. E. Kirk, Professor of Electrical and Computer Engineering and R. D. Strum, Professor Electrical and Computer Engineering

SPONSOR: Strategic Systems Project Office

OBJECTIVE: The objectives are to develop computer-aided techniques and apply them to control design tasks of interest in the Trident II Program and to utilize VLSI design techniques to develop components for high-speed digital filters.

SUMMARY: Three performance measures were investigated for the design of constant-gain estimators. The (simulated) performance of worst-case and mean quadratic integral error squared was better than that observed for other performance measures. The approach used was also extended to allow determination of worst-case and best-case performance for a given observer. This allows consideration of sensitivity to initial errors. Finally, the technique was used to develop measures of the relative observability of a system's state, an area of continuing investigation. The goal is to develop a way to determine the performance benefits that result if different sensors are used to obtain state measurements. Or, an understanding may be obtained of the limitations inherent in the system with respect to the estimation of the various states from output measurements. A second area of investigation was the development of interactive Computer-Aided Design (CAD) tools for analysis and design of control systems. These tools were then applied to the TVCEEC problem. It was shown that constant gain observers performed as well as Kalman filters considered in previous work, but sensitivity to plant parameter variations is still a problem.

The VLSI design studies were concerned with the development of a pipelined multiplier. The multiplier were designed using the MacPitts silicon compiler. After extensive simulation, the design was sent for fabrication. The fabricated chip was tested to the limits of our capability, and is functionally correct. Additional tests are needed to determine the maximum speed at which the circuit can be operated.

THESES DIRECTED:

Frank Forkel, "Design and Sensitivity Analysis of an Optimal Observer for the Trident II Missile TVC-EEC Control System," Master's Thesis, December 1983.

Alden Hingle, "A Study of Quadratic Performance Measures in Observer Design," Master's Thesis, December 1983.

Dennis J. Carlson, "Application of a Silicon Compiler to VLSI Design of Digital Pipelined Multipliers," Master's Thesis, June 1984.

TITLE: Advanced Antiship Targeting Program

INVESTIGATOR: C-H Lee, Associate Professor of Electrical and Computer Engineering

SPONSOR: Naval Weapons Center

OBJECTIVE: To help develop classification algorithm on flying platform

SUMMARY: This task is to provide a testing facility for evaluation of image segmentation algorithms from five contractors: Ford Aerospace, General Dynamics, Hughes Aircraft, RCA and McDonnell Douglas Corporation. A test facility at the Naval Postgraduate School includes the VAX 11 750 super minicomputer, the COMTAL image processing system, and the appropriate evaluation software. Most of the effort was concentrated on the preparation of the test procedures. The initial segmentor test was scheduled on October 2 to 4. The results will be published and distributed among members of the community.

PUBLICATIONS: C-H Lee, "AATD Segmentor Test General Procedure," NPS Research Report, November 1984.

THESES DIRECTED: Werawong Thavamongkon, "Ship Outline Feature Selection Using B-Spline Function," Master's Thesis, December 1984.

Stephen S. Payne, "Ship Target Recognition Using Multiple Frame Data," Master's Thesis, June 1985.

TITLE: Image Processing Research

INVESTIGATOR: C-H Lee, Associate Professor of Electrical and Computer Engineering

SPONSOR: Naval Electronic Systems Command

OBJECTIVE: Applying the algorithm of recursive segmentation with hierarchical scope views to digital aerial photographs. The purpose is to investigate the sensitivity improvement of this algorithm.

SUMMARY: The purpose of this work is to conduct basic research addressing problems related to image processing. This research is to address both computer analysis and hardware implementation aspects of image processing using concise spatial features of irregular piecewise polynomial surfaces. Implementation of this feature extraction procedure in VLSI shall be considered. A large computer may be used for both verification of the process and design of the hardware.

One goal of this work is to improve the performance of existing algorithms for region segmentation applied to high resolution aerial photographs. A Recursive Splitting method at hierarchical scopic levels will be developed and implemented. This requires a special data structure constructed in the memory space of the computer. To evaluate this scheme, it is necessary to implement this structure in a virtual memory machine. The iteration criterion in the algorithm will include diagonal profile consideration. Special problems caused by discontinuous boundaries from splitting at different levels will be solved by "adjacency propagation of thresholds".

PUBLICATIONS: L. Souza and C-H Lee, "Fundamentals of Systolic Array Computers," NPS Research Report, November 1984.

THESIS DIRECTED: H. S. Hwang, "Computer Display of 3-D Data," Master's Thesis, December 1984.

L. J. DeSouza, "Algorithmic Study of Systolic Array," Master's Thesis, June 1985.

TITLE: Image Data Compression and Representation by Piecewise Surfaces Over Irregular Patches

INVESTIGATOR: C-H Lee, Associate Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: This is a study of the surface representation of image data. An image surface can be presented as a collection of irregular patchs of parametric spline surfaces. This study is concentrated on maximizing the achievable data compression ratio.

SUMMARY: One of the important issues in processing digital images is related to the total volume of data involved. How to store the images, how to retrieve them, and how to process them in realistic time? Many efforts were spent in investigating clever ways to code the image so that the total data is compressed. For a regular 512 x 512 element picture with 256 levels of gray it is necessary to required a storage capacity of 64 binary megabytes (2^{26}) to accommodate it. For multiple-image processing or change detection in a sequence of time frame images the storage capacity problem becomes serious quickly. The research effort proposed here is aimed at the image data compression problem.

PUBLICATIONS: C-H Lee, "Restoring Spline Interpolation of CT Images," IEEE Transaction on Medical Imaging, Volume MI-2, No. 3, pp. 142-149, September 1983

C-H Lee, "Recursive Region Splitting at Hierarchical Scope Views," submitted to Computer Vision, Graphics and Image Processing, in progress.

THESIS DIRECTED: C. T. DeMiranda, "Image Data Compression Using Uneven Knot Positions," Engineer's Degree Thesis, June 1984

TITLE: Field Expedient Antenna Investigations

INVESTIGATORS: H-M Lee, Assistant Professor of Electrical and Computer Engineering and R. W. Adler, Adjunct Professor of Electrical and Computer Engineering

SPONSOR: Naval Ocean System Center

OBJECTIVE: Theoretical investigations and field testing of field expedient antennas currently in use by the U.S. Marine Corps.

SUMMARY: Field expedient antennas currently in use by the U.S. Marine Corps and Navy Seals were investigated and field tested. Antenna selection and design algorithms were implemented on a microcomputer. An upgraded version of the USMC Field Antenna Handbook was produced.

PUBLICATIONS: USMC Field Antenna Handbook (upgrade)

THESIS DIRECTED: W. P. Averill, "Computer-Aided Design and Frequency for HF Communications," Master's Thesis, June 1984.

TITLE: Perturbative Model Analysis of the Back-Scattering Characteristics of a Missile over Several Frequency Bands

INVESTIGATOR: H-M Lee, Assistant Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVES: (1) To develop an analytic theory on the scattering of electromagnetic waves from tubular cylinders of finite length. This will add to the list of only a few finite sized objects of which the vector scattering problems have been analytically solved.

(2) To apply this theory toward the identification and the reduction of the cross sections of targets with increasingly complex shapes.

SUMMARY: A theory of the scattering surface current on a tubular cylinder was developed and is now being compared to experimental results. Based on this theoretical understanding, scattering data from models with small deviations from a tubular cylinder will be interpreted. Phenomenological theories on these perturbed models will be developed.

CONFERENCE PRESENTATIONS: H-M Lee, "Interaction of Modal Currents on a Tubular Cylinder of Finite Length,", 1984 URSI & IEEE AP-S International Symposium at Boston.

THESIS DIRECTED: Mario Loric, "Radar Target Identification through Electromagnetic Scattering Studies," Master's Thesis, December 1984.

TITLE: Inherent Tracking Errors of a Monopulse Radar

INVESTIGATOR: H-M Lee, Assistant Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: To study the inherent angular tracking errors of monopulse radars and to develop, based on the findings of this study, countermeasures against this type or radar.

SUMMARY: A radar is designed for tracking a point target but is always used for tracking a complex target. This will result in errors in the estimated target location by the radar. This type of error has been discussed over the previous 25 years without its origin being recognized. Related problems have been over-simplified and journal publications have been infested with erroneous claims. This research is intended to point out the inadequacies in previous work and to lay the foundation for future developments in this area.

THESES DIRECTED: Dae Hyun Park, "Inherent Angular Tracking Error in an Amplitude Comparison Monopulse Radar," Master's Thesis, December 1984.

Sopon Bumroongpol, "Angular Tracking Error in a Phase Comparison Monopulse Tracking Radar: A Critical Review and Extension of the Phase Front Distortion Approach," Master's Thesis, December 1984.

TITLE: Research and Development of Computer Algorithms for Search Systems.

INVESTIGATOR: H. H. Loomis, Jr., Adjunct Research Professor of Electrical and Computer Engineering.

SPONSOR: Department of Defense

OBJECTIVE: This project is concerned with the development of hardware architectures and algorithms to support specific projects of the Office of Search.

SUMMARY: We have been conducting research to support the objectives of this project in three areas:

a. The evaluation of candidate algorithms for computing the cyclic spectrum of noisy signals. This has involved extensive simulation studies of signal processing functions developed by Dr. William Gardner.

b. The investigation of architectures for high speed signal processing making use of pipeline techniques in particular. In this area, we have studied the architecture and performance of a pipeline structure optimized to achieve high performance in the calculation of FFTs. We have also developed some theoretical results on the design of pipelined digital filters.

c. The definition of a language to define the structure of complex digital communication signals.

PUBLICATIONS: H. H. Loomis, Jr. and B. Sinha, "High Speed Realization of Recursive Digital Filters," to appear in Circuits and Signal Processing, Vol. 3, No. 3, 1984.

J. Pride, H. H. Loomis, Jr., and W. Hickey, "A Signal Descriptor Language," to appear in Cryptologic Quarterly, National Security Agency, 1985.

THESES DIRECTED: Laurvick, C. A., "Detection of Spread Spectrum Communication," Masters Thesis, June 1984.

Thomas Lorenzo, Jr., "Design Considerations of Pipeline Array Processors", Masters Thesis, December 1983.

TITLE: Research and Development of Computer Applications and algorithms for Navy Space Systems.

INVESTIGATORS: H. H. Loomis, Jr., Adjunct Research Professor of Electrical and Computer Engineering, and A. A. Ross, Assistant Professor of Computer Science.

SPONSOR: Naval Electronic Systems Command, PDE 106-5

OBJECTIVES: To apply the expertise of the faculty investigators and NPS students through thesis research on the computer architecture and algorithm related problems of the Navy Space Program.

SUMMARY: Computer architectures and algorithms are a vital component of all aspects of the Navy Space Program. We have been concentrating on end-user tactical information systems and the issues of computer architecture and algorithms as they relate to such systems. We have investigated the use of expert systems designed to develop scenarios from complex collections of tactical information. We have also been working on the methods for applying geographic knowledge (i.e. maps) to scenario development. We have analyzed the results of Special Project Night Raider from the point of view of the surface warfare officer as a tactical user. This project has developed important insight into the utility and tactical employment of TADIXS-B, a proposed tactical data link. We have also studied an important real-time computer system from the point of view of the operator, applying principles of human engineering. We have been working closely with NRL and a contractor on the computer architecture of a spaceborne special purpose computer. We are also assisting in the development of automatic microcode generators for a bit slice microprocessor.

THESES DIRECTED: H. Taylor, "Computerization of Surface Direct Support Operation," March 1984.

R. J. Beaver, "Evaluation of the Tactical Utility of TADIXS-B from Data Collected During the TADIXS-B Simulation", Masters Thesis, June 1984.

S. Harding, "Man-machine Interaction: Operator", Masters Thesis, June 1984.

TITLE: Applications of Composite Operational Amplifiers in Linear and Non-linear Networks

INVESTIGATORS: Sherif Michael, Adjunct Professor of Electrical and Computer Engineering

SPONSOR: Unsponsored research conducted during full-time teaching period.

OBJECTIVE: To investigate the advantages of using the composite operational amplifiers in different analog circuits.

SUMMARY: Recently, a general approach for designing controlled sources by combining N OAs has been proposed by the investigator with applications to Voltage Controlled Voltage Sources (VCVS). The new resulting Composite Operational Amplifier families (CNOAs), were designed according to a stringent performance criterion satisfying practical aspects such as dynamic range, Extended BW, insensitivity to components and GBWP, stability using real OA model, etc. In this ongoing research, application of C2OAs (where N=2) in improving the performance of Generalized Immittance Converters (GIC) is investigated theoretically and experimentally. The research also evaluates similar applications in nonlinear networks.

PUBLICATIONS: S. Michael and W. B. Mikhael, "High Frequency Active Generalized Imittance Converters and Their Applications in Filtering," Proceedings of the 26th Midwest Symposium on Circuits and Systems, Puebla, Mexico, August 1983, pp. 597-601.

S. Michael and W. B. Mikhael, "High-Speed, High-Accuracy Integrated Operational Amplifiers," Proceedings of the 27th Midwest Symposium on Circuits and Systems, Morgantown, WV, June 1984.

S. Michael and W. B. Mikhael, "High Frequency Filtering and Inductance Simulation Using New Composite Generalized Imittance Converters," Proceedings of the IEEE International Symposium on Circuits and Systems, Kyoto, Japan, forthcoming.

CONFERENCE PRESENTATIONS: S. Michael, "High-Speed, High-Accuracy Integrated Operational Amplifiers," 27th Midwest Symposium on Circuits and Systems, Morgantown, WV, June 1984.

TITLE: Naval Electronic Systems Command Research Chair in Electrical and Computer Engineering

INVESTIGATOR: R. R. Mohler, NAVELEX Research Chair Professor, Department of Electrical and Computer Engineering

SPONSOR: Naval Electronic Systems Command

OBJECTIVE: Application of bilinear system methodology to C^3 problems.

SUMMARY: Briefly, it has been shown that coupled bilinear systems (BLS) play a very significant role in C^3 problems because of their natural evolution for maneuvering rigid bodies, for combating forces (of which Lanchester's equations are special cases), for high-performance adaptive command and control, and for accurate approximations of more highly nonlinear C^3 processes. It is interesting that the human immune defense system, like many national defense C^3 processes, may be modeled as a BLS hierarchical structure. For both cases, it is the variable-structure or adaptive nature that allows the "alien" to be controlled.

Pursuit-evasion problems that have been studied include minimum-time and minimum-quadratic performance (error and fuel) for competing forces. In particular, linear models with n-pursuers "capturing" a target within some radius has been studied as an extension of the one-on-one solution. Improved performance vs C^3 complexity has been analyzed for n-pursuers as compared to one pursuer or more. It is seen that command, control, computation and communication between objects (e.g. ships or planes) increases significantly with additional pursuers. On the other hand, two or three pursuers, strategically located, can "capture" an otherwise extremely elusive evader. While these results have been derived by preliminary analyses and numerous computer simulations, the general n-pursuer problem is still unsolved. Approximating techniques using a combination of one-on-one configurations in an "ensemble" are being investigated.

PUBLICATIONS: Included in attachment

TITLE: Nonlinear Filtering and Tracking

INVESTIGATOR: R. R. Mohler, NAVELEX Research Chair Professor, Department of Electrical and Computer Engineering

SPONSOR: Office of Naval Research

OBJECTIVE: Development of new nonlinear signal processing methodologies appropriate for acoustical underwater tracking.

SUMMARY: Related research on nonlinear filtering has studied localization of point targets by means of nonlinear observations. Maneuvering targets have been studied, and effective algorithms derived which depend on smoothing of the error residuals and adaptively reinitializing the tracking scheme. The method is applicable to standard (linear or nonlinear) processors with improved performance for maneuvering cases. Other studies include target observability in terms of maneuvers, number of receivers, and receiver information (such as range, bearing, Doppler, etc.). The theory is relevant to not only aircraft and seaborn surveillance but also to satellite-based systems.

PUBLICATIONS: Included in attachment

TITLE: Acoustic Tactical Data Link

INVESTIGATOR: P. H. Moose, Associate Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

SUMMARY: Based on the feasability analysis conducted by LT John Lambert, an ASW student at NPS, we have initiated research activities to develop the various components of a high data rate underwater acoustic communications link. A message generator and encoder has been completed during the summer of 1984. The coherent multi-tonal, phase shift keyed digital transmitter is being designed as a thesis project by an ECE student, LCDR DeFrank. A parametric acoustic projector has been acquired from NUSC/NL. Foundation funds were used to purchase the 1500 volt power supply required to operate this transducer.

Plans for 1985 are:

1) To conduct research on the digital sonobouy receiver.

2) To test the transmitter with the parametric projector for power output, directionality and signal fidelity. Funding will be sought from external NPS sources.

TITLE: Dynamics of Battles, Encounters and Engagements and the Correlation of Forces in Information Driven Warfare

INVESTIGATORS: P. H. Moose, Associate Professor of Electrical and Computer Engineering and J. M. Wozencraft, Professor of Electrical and Computer Engineering

SPONSOR: None

OBJECTIVE: To understand the dynamics of modern warfare and to be able to define the possible outcomes of battle with various force mixes.

SUMMARY: During the past two years, we have investigated evolution mathematics specialized toward battles involving mixtures of high technology weapons and conventional forces. A number of preliminary results have been obtained: an optimum force mixture at each stage of the battle, optimum initial commitment of forces vice forces held in reserve, conditions for successful defense of positions already occupied until reinforcements arrive, and the relative level of high technology weapons to insure initial victories.

All of these results are theoretical. However, some data from post WW II battles have been examined to determine that our paradigm is not grossly incorrect. But what is emerging from our studies is potentially more significant than any of these results. To the extent that evolution mathematics provides an instructive model of Battles nd Engagements, we now know that the trajectory of the battle in the state space of component losses is ultimately restricted to travel in a "tube". The location of this "tube" in the state space is determined by the relative characteristics of the weapons and effectiveness of the combat forces as well as the logistic system that keeps them supplied. This is our conception of "Correlation of Forces". Given a particular tube then the combat loss trajectory will be "attracted to the tube" if the initial conditions of the Battle locate the start point outside it. Once inside the tube, the trajectory is trapped inside it, that is, the loss trajectory travels parallel to the "walls of the tube". The direction of travel, that is who is winning or who is losing, is determined by the "polarity of the tube". The tube's polarity is another of the deterministic properties of this model and it reverses as the tube passes through equilibrium points.

PUBLICATIONS: John M. Wozencraft and Paul H. Moose, "Lanchester's Equations and Game Theory,", Proceedings of the 6th MIT/ONR Workshop on C^3 Systems, June 1983.

THESIS DIRECTED: B. N. Ang, "Equilibrium Solutions, Stabilities and Dynamics of Lanchester's Equations and Optimization of Initial Force Commitments," Master's Thesis, September 1984.

Title: Measurement of Natural Resonance Parameters for Radar Target Identification

Investigator: M. A. Morgan, Associate Professor of Electrical and Computer Engineering

Sponsor: Office of Naval Research

Objective: To advance the state of the art in experimental and theoretical techniques for radar target identification through the use of natural resonances extracted from scattered echo signatures.

Summary: Theoretical and experimental work in the areas of target recognition and imaging via transient scattering responses has been an ongoing effort at the Naval Postgraduate School (NPS) for the past 5 years. This research was initially sponsored through the NPS Research Foundation and was first approached via direct target imaging. This continued effort, sponsored by ONR, utilizes natural resonances.

There are three particular aspects of this present endeavor. The first of these is the continued developement and improvement of a computerized experimental facility which synthesizes wide-band resonance region radar returns, and then performs subsequent signal processing to simulate the operations of proposed noncooperative target recognition (NCTR) systems. A second important task will be to catalog the measured natural resonances of a wide variety of radar targets, which are of interest to the Navy, through the use of scale models. A third aspect of this research has been the detailed theoretical analysis of transient scattering and the nature of the natural resonances in the received scattered field. Recent revelations brought forth by this analysis have modified the signal processing strategies that are required for natural resonance NCTR.

Publications:

M. A. Morgan, "Singularity Expansion Representations of Fields and Currents in Transient Scattering," IEEE Trans. on Antennas and Propagation, May 1984, pp. 466-474.

M. A. Morgan, "Time-Domain Scattering Measurements," IEEE Antennas and Propagation Society Newsletter, Feature Artice including Front Cover, pp. 4-9.

Conference Presentation(s)

M. A. Morgan, M. L. Van Blaricum, J. R. Auton, "On the Practicality of Resonance-Based Identification of Scatters," 1984 URSI National Radio Science Meeting, Boston, MA, June 1984.

Thesis Directed:

"Development, Calibration and Evaluation of a Free-Field Scattering Range," Manual A. Mariategui, LT, Peruvian Navy, M.S. Thesis, December 1983.

"Investigation of Non-Linear Estimation of Natural Resonances in Target Identification," Choong Y. Chong, LT, Korean Navy, M.S. Thesis, December 1983.

"Radar Target Identification by Natural Resonance Cancellation Filtering," King W. Jean, CPT, Canadian Army, M.S. Thesis, June 1984.

"Investigation of Radar Scattering Reduction by Distributed Methods," Dale E. Stoehr, LCDR, USN, M.S. Thesis, June 1984.

"A Stepped-Frequency Scattering System: Setup and Evaluation," Dennis M. Popiela, LT, USN, M.S. Thesis, September 1984.

Title: Transient Scattering and Signal Processing

Investigator: M. A. Morgan, Associate Professor of Electrical and Computer Engineering

Sponsor: Defense Advanced Research Projects Agency (DARPA)

Objective: Using transient electromagnetic scattering measurements from scale model radar targets the broadband RCS is evaluated for Rayleigh and Resonance region frequencies.

Summary: This is a continuing investigation concerning the optimum synthesis of radar cross section (RCS) from transient measurements of scattering. Three particular tasks have received intensive consideration. There has been an in-depth study and measurements concerning s-plane RCS measurement not in the theoretical - experimental study regarding the physical SEM representation of target transient response in the early-time while under driver excitation and to consider the implications of this regarding signal processing strategies and s-plane representation of RCS. Finally, there has been development of an optimal theoretical technique for system deconvolution which will be used for scatterer impulse response synthesis. Near-term future efforts call for the construction of a new anechoic chamber for improved scattering measurements capabiltiy.

Publications: M. A. Morgan, "Singularity Expansion Respresentations of Fields and Currents in Transient Scattering," IEEE Trans. on Antennas and Propagation, May 1984, pp. 466-474.

M. A. Morgan, "Time-Domain Scattering Meausrements," IEEE Antennas and Propagation Society Newsletter, Feature Article including Front Cover, pp. 4-9.

Conference Presentation(s):

M. A. Morgan, M. L. Van Blaricum, J. R. Auton, "On the Practicality of Resonance-Based Identification of Scatters," 1984 URSI National Radio Science Meeting, Boston, MA, June 1984.

Thesis Directed:

"Development, Calibration and Evaluation of a Free-Field Scattering Range," Manual A. Mariategui, LT, Peruvian Navy, M.S. Thesis, December 1983.

"Investigation of Non-Linear Estimation of Natural Resonances in Target Identification," Choong Y. Chong, LT, Korean Navy, M.S. Thesis, December 1983.

"Radar Target Identification by Natural Resonance Cancellation Filtering," King W. Jean, CPT, Canadian Army, M.S. Thesis, June 1984.

"Investigation of Radar Scattering Reduction by Distributed Methods," Dale E. Stoehr, LCDR, M.S. Thesis, June 1984.

"A Stepped-Frequency Scattering System: Setup and Evaluation," Dennis M. Popiela, LT, USN, M.S. Thesis, September 1984.

TITLE: Discrete Time Signal Processing for Modeling and Filtering

INVESTIGATOR: S. R. Parker, Professor of Electrical and Computer Engineering

SPONSOR: Office of Naval Research

OBJECTIVE: Research in the development and implementation of algorithms for multidimensional and nonlinear discrete time signal processing for purposes of system modeling, identification and digital filtering.

SUMMARY: It has been shown that by regrouping the terms of a Volterra expansion for a nonlinear system (in the order of a power series, rather than in the order of time delay) a compact tensor notation is possible from which tensor equivalents of the Weiner-Hopf and Yul-Walker equations are possible. The technique has been extended to a basis function expansion, and it has been shown that a simple transformation from one type of expansion to another is possible. Results have been confirmed experimentally, and applied to a recursive least square model approximation which involves the concept of a tensor inverse.

Also, the concept of one dimensional lattice parameter modeling, which has been used so successfully in the past for modeling of the voice tract for speech analysis, synthesis and data compression; has been extended to two dimensional fields. This work represents a fundamental development and has significant ramifications which remain to be investigated. Preliminary applications of this research which have been investigated thus far include: (a) Word recognition based upon the identification of voice prints as images, (b) Image data filtering for data compression, (c) Two-dimensional recursive digital filter design, (d) Two-dimensional spectral estimation.

PUBLICATIONS: S. R. Parker and A. H. Kayran, "Lattice Parameter Autoregressive Modeling of Two-Dimensional Fields - Part I: The Quarter Plane Case," IEEE Transactions on Acoustics, Speech and Signal Processing, Vol ASSP-32, No. 4, pp. 872-885, August 1984.

S. R. Parker and A. H. Kayran, "Lattice Parameter Autoregressive Modeling of Two Dimensional Fields - Part II: The Half Plane Case," IEEE Transactions on Acoustics Speech and Signal Processing, in progress.

Y. Lim and S. R. Parker, "FIR Filter Design Over a Discrete Powers-of-Two Coefficient Space," IEEE Transactions on Acoustics, Speech and Signal Processing, VOL ASSP-31, No. 3, pp. 583-591, June 1983.

G. A. Clark, S. R. Parker, and S. K. Mitra, "A Unified Approach to Time- and Frequency-Domain Realization of FIR Adaptive Digital Filters," IEEE Transactions on Acoustics, Speech and Signal Processing. Vol 31, No. 5, pp. 1073-1083, October 1983.

Y. C. Lim and S. R. Parker, "On the Synthesis of Lattice Parameter Digital Filters," IEEE Transactions on Circuits and Systems, Vol CAS-31, No. 7, pp. 593-601, July 1984.

A. H. Kayran, Y. C. Lim and S. R. Parker, "Decimation Technique for Optimal Data Transfer in One- and Two-Dimensional FIR Digital-filter implementation," IEE Proceedings, Vol. 131, Pt. G, No. 2, pp. 86-89, April 1984

F. A. Perry and S. R. Parker, "Transition Formulas for Zero-Pole Modeling," IEEE Transactions on Acoustics Speech and Signal Processing, Vol ASSP-32, No. 1, pp. 178-184, February 1984.

Y. C. Lim and S. R. Parker, "On the Identification of Systems From Data Measurements Using ARMA Lattice Models," IEEE Transactions on Acoustics Speech and Signal Processing, in progress.

CONFERENCE PRESENTATIONS:

S. R. Parker, "Modeling of Two-Dimensional Fields with Autoregressive Lattice Parameters," Proceedings of the American Control Conference, WA 9-10:15 San Diego, pp. 216-221, June 1984.

J. J. Thomas and S. R. Parker, "An Implementation of a Fast Recursive Digital Filter Using Single-Modulus Residue Arithmetic," Proceedings of the 1984 International Symposium on Circuits and Systems, May 1984.

A. H. Kayran, S. R. Parker and D. J. Klich, "Two-Dimensional Spectral Estimation with Autoregressive Lattice Parameters," Proceedings of the IEEE 1984 International Conference on Acoustics, Speech and Signal Processing, 1984.

Y. C. Lim and S. R. Parker, "Efficient FIR Filter implementation Using Microprocessor," Proceedings of the 1983 International Conference on Acoustics Speech and Signal Processing, 1983.

Y. C. Lim, A. H. Kayran and S. R. Parker, "A Decimation Technique for Optimal Data Transfer in One- and Two-Dimensional FIR Digital Filter Implementations," Proceedings of the IEEE International Conference on Circuits and Systems, pp. 1079-1082, 1983.

A. H. Kayran, S. R. Parker and H.Canbazoglu, "Design of 2-D Digital Recursive Filters with Autoregressive Lattice Parameters," Proceedings of the IEEE International Symposium on Circuits and Systems, 1984.

C. B. A. Shawcross, S. R. Parker and A. H. Kayran, "Isolated Word Recognition and Speaker Identification Using Two-Dimensional Half-Plane Lattice Parameters of Spectrograms," Proceedings of the International Conference on Digital Signal Processing, September 1984.

S. R. Parker and A. H. Kayran, "Lattice Parameter Autoregressive Modeling of Two-DimensionalFields," Proceedings of the IEEE ASP Spectrum Estimation Workshop, pp. 219-223. November 1983.

J. J. Thomas and S. R. Parker, "A Viable Technique of Calculating Algorithms to any Specified Accuracy," Signal Processing II: Theories and Applications, pp. 783-786, 1983.

M. Fidan, S. R. Parker and A.H. Kayran, "Calculating Quantization Error Bounds for 2-D Recursive Digtal Filters," Signal Processing II: Theories and Applications, pp. 215-218, 1983.

Y. C. Lim, A. H. Kayran and S. R. Parker, "Efficient Positive Coefficient Algorithm for Array Processing,: Electronic Letters, Vol 19, No. 9, April 1983.

THESES DIRECTED:

D. L. Mauney, "Sensitivity Analysis Modeling for Discrete-time Simulation of Analog Circuitry," Master's Thesis, March 1984.

C. B. A. Shawcross, "The Use of Two Dimensional Lattice Models in Isolated Word Recognition," Engineer's Degree, December 1983.

A. H. Canbazoglu, "Design of Two-Dimensional Recursive Digital Filters Using Lattice Parameters," Master's Thesis, December 1983.

D. Bozkurt, "The Use of 2-D Lattice Modeling for Image Coding and Processing," Master's Thesis, December 1984.

Z. S. Chavez, "Lattice Modeling of an Analog System for Fault Location," Master's Thesis, October 1983.

TITLE: Propagation of Scalar Acoustic Waves

INVESTIGATORS: Daniel Guyomar, National Research Council Associate and John Powers, Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: To apply spatial frequency domain techniques to the modeling to the propagation of pulsed and transient scalar waves in lossless and lossy media. The technique would allow the application of computer-efficient FFT algorithms to problems that have previously used more complicated integrals based on geometrical interpretation.

SUMMARY: Techniques have been identified and used in computer simulations that model the propagation in (1) lossless media, (2) media with an absorption coefficient that is liner with frequency, and (3) media with an absorption that is quadratic in frequency. The techniques have been used to model transient propagation from focused transducers and planar sources. Additionally simplifications have been identified that increase the computational efficiency of the technique in calculating the fields from axisymmetric transducers.

PUBLICATIONS: D. Guyomar and J. Powers, "Diffraction of Publsed Ultrasonic Waves in Lossless and Absorbing Media," in progress.

D. Guyomar and J. Powers, "Transient Fields Radiated by CurvedSurfaces--Application to Focusing," Journal of the Acoustical Society of America. Vol. 75, pp. 1564-1572, 1984.

D. Guyomar and J. Powers, "Boundary Effects on Transient Radiation Fields from Vibrating Surfaces," Journal of the Acoustical Society of America, forthcoming.

D. Guyomar and J. Powers, "Transient Radiation from Axially Symmetric Sources," in progress.

CONFERENCE PRESENTATIONS: D. Guyomar and J. Powers, "Diffraction of Pulsed Ultrasonic Waves in Lossless and Absorbing Media," 107th Meeting of the Acoustical Society of America, Norfolk, VA, 7-10 May 1984.

TITLE: Solid Propellant Combustion

INVESTIGATORS: David Netzer, Professor of Aeronautics, and John Powers, Professor of Electrical and Computer Engineering

SPONSOR: Air Force Rocket Propulsion Lab

OBJECTIVE: To conduct an experimental investigation of the effects of solid propellant properties and motor operating conditions on metallized particulates within the combustor and exhaust nozzle. The techniques investigated are: high speed motion pictures, holography, light scattering, and scanning electron microscopy. Additionally techniques of automatic data reduction from holograms of the particulates were investigated.

SUMMARY: In automatic data reduction, the overlying speckle is observed to limit resolution of the particles. Analysis was performed to identify the source of the limiting speckle size and to modify the recording and reconstruction geometry of the hologram to reduce speckle to a minimum. A Quantimet 720 image processing system was obtained and operator training on obtaining particle size histograms was done using photographs of hologram reconstructions. This system has also been used to examine images from holograms and to measure the speckle. The hologram has been mounted on a digitally controlled stage to provide three dimensional precision motion of the reconstruction volume.

PUBLICATIONS:

J. Powers, D. Netzer, et al, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," Technical Report AFRL TR-84-014, Air Force Rocket Propulsion Laboratory, Edwards Air Force Base, 1984.

D. Netzer, J. Powers, et al, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," Proceedings of the 20th JANNAF Combustion Meeting, (Chemical Propulsion Information Agency, Publication No. 883, John Hopkins University Applied Physics Laboratory, Laurel, Maryland, 1984), pp. 319-332.

CONFERENCE PRESENTATIONS:

D. Netzer, J. Powers and others, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," 20th JANNAF Combustion Meeting, Monterey, CA, 17-20 October 1983.

D. Netzer, J. Powers and others, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," 1984 AFOSR/AFRL Rocket Propulsion Research Meeting, Lancaster, CA, 12-15 March 1984.

THESIS DIRECTED:

L. Klooster, "Image Processing of Solid Propellant Combustion Holograms Using the Quantimet 720," Master's Thesis, December 1983.

TITLE: Fixed Distributed Systems: Environmental Acoustics and Fiber Optic Communications

INVESTIGATORS: Calvin Dunlap, Adjunct Research Professor of Oceanography, John Powers, Professor of Electrical and Computer Engineering, Eugene Haderlie, Distinguished Professor of Oceanography and Bryan Wilson, Professor of Physics.

SPONSOR: Defense Advanced Research Projects Agency

OBJECTIVE: To investigate the environmental effects on fixed distributed acoustic systems by study of a sample system to be installed in Monterey Bay. Additional study is one the use of fiber optic cables for transmitting the data.

SUMMARY: In this new project a long-wavelength single-mode fiber optic system has been designed for installation at high data rates. Supplies and instrumentation have been identified and ordered for the laboratory construction and testing of the fiber optic link. A candidate fiber cable has been successfully tested in a towing configuration for mechanical robustness. Several over-the-shore fiber links will be installed and periodically evaluated for study of survivability in the surf environment. Additionally, a short course on fiber optic communications was given at NPS to twenty-five project personnel as part of this project.

TITLE: Automatic Radar Ship Classification for Cruise Missiles

INVESTIGATOR: L. A. Wilson, Associate Professor of Electrical and Computer Engineering

SPONSOR: Joint Cruise Missile Project Office

OBJECTIVE: To develop automatic radar ship classification techniques and ESM systems for cruise missile applications.

SUMMARY: This research provides theoretical analysis, computer analysis, and system design of an Automatic Radar Ship Classification System for Cruise Missile applications. The primary efforts were centered on classification rates vs. number of ship classes, classification rate vs. ship categories, classification rates vs. radar range resolution, classification rates vs. signal-to-noise ratios, and classification rates for simulated cruise missile seeker signatures. Thesis students participated heavily in this task. The application of artificial intelligence techniques was initiated to help solve the classification problems.

Development of an improved ESM system for Cruise Missile application was started. Experimental Modulation on Pulse (MOP) signatures have been collected for several U.S. radar systems. The wideband MOP measurement system, developed under this task, has much superior performance capabilities when compared with other known systems.

PUBLICATIONS:

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 3 and Resolution No. 3," NPS Working Report, May 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 6 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 2 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 7 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 8 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 7 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 6 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 8 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 9 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 2 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 3 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 1 and Resolution No. 2," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 2 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 4 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 5 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 6 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 7 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 8 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship NO. 9 and Resolution No. 2," NPS Working Report.

THESES DIRECTED:

Richard D. Snook, "Experimental Measurements of Modulation on Pulse (MOP) Characteristics of Several Radars," Master's Thesis, September 1984.

G. Douglas Thrash, "Experimental Modulation on Pulse (MOP) Characteristics of Selected NPS Radars," Master's Thesis, June 1984.

Paul A. White, "Experimental Frequency Modulation on Pulse (FMOP) Signatures of Selected Radars," Master's Thesis, September 1984.

David Miller, "An Investigation of the Relative Importance of Fourier Phase for Radar Target Classification," Master's Thesis, March 1984.

Scott Boyd, "Frequency Modulation on Pulse Characteristics of the 4J50 Magnetron," Master's Thesis, September 1984.

TITLE: Multi-Source Track Management

INVESTIGATOR: L. A. Wilson, Associate Professor of Electrical and Computer Engineering

SPONSOR: Naval Sea Systems Command

OBJECTIVE: To develop the Multi-Source Track Management system for the next generation ACDS.

SUMMARY: The theoretical analysis and system tradeoff analysis for the Multi-Source Track Management was continued. The successful integration of ESM, Radar, EO, IR, and Acoustic sensors will significantly benefit ACDS capabilities. Two thesis students have completed efforts on integrating ESM sensor information into the ACDS system. The AN/SLQ-17 ESM system and AN/SLQ-32 system were independently integrated into ACDS. ESM similar source integration, emitter signal sorting, emitter classification, and identification, and emitter classification to platform correlation were included in the analysis.

THESIS DIRECTED: Kenneth G. Lombart, "The Integration of Naval Assets the SSN in ACDS," Master's Thesis, June 1984.

TITLE: Underwater Acoustic Propagation and Scattering in a Random Ocean - A Linear Systems Theory Approach

INVESTIGATOR: L. J. Ziomek, Assistant Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: To derive transfer functions and coherence functions of the random ocean medium based upon the WKB and parabolic equation approximations. By coupling the transfer functions to various transmit signals and transmit and receive apertures, problems in pulse propagation, underwater acoustic communication, and target detection will be studied via computer simulation of the derived mathematical expressions.

SUMMARY: A time-invariant, space-variant, random transfer function of the ocean volume was derived using the parabolic equation approximation. The ocean volume was characterized by a three-dimensional random index of refraction. The index of refraction was decomposed into a deterministic component and a zero mean random component. In addition, two example calculations were made using the transfer function. The first example involved the derivation of the equations for the random, output electrical signals at each element in a receive planar array of complex weighted point sources in terms of the frequency spectrum of the transmitted electrical signal, the transmit and receive arrays, and the transfer function of the ocean medium. The second example involved the derivation of the coherence function, i.e., the autocorrelation function of the transfer function.

Computer simulation of the equations for the output electrical signals based on the WKB approximation began. A three-dimensional FFT beamformer space-time signal processing algorithm was used to process the computer simulated signals in order to study problems in source localization and underwater acoustic communications.

PUBLICATIONS: L. J. Ziomek, "Linear Time-Variant Space-Variant Filters and the WKB Approximation," Naval Postgraduate School Technical Report, NPS-62-83-058, October 1983.

L. J. Ziomek, "Linear Time-Invariant Space-Variant Filters and the Parabolic Equation Approximation," Signal Processing, in progress.

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